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GROWTH OF THE SEAGRASS *POSIDONIA SINUOSA* CAMBRIDGE *ET* KUO AT LOCATIONS NEAR TO, AND REMOTE FROM, A POWER STATION THERMAL OUTFALL IN NORTHERN SPENCER GULF, SOUTH AUSTRALIA

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Summary

AINSLIE, R. C., JOHNSTON, D. A., & OFFLER, E. W. (1994). Growth of the seagrass *Posidonia sinuosa* Cambridge *et* Kuo at locations near to, and remote from, a power station thermal outfall in northern Spencer Gulf, South Australia. *Trans. R. Soc. S. Aust.* **118**(3), 197-216, 30 November, 1994.

The growth of the seagrass *Posidonia sinuosa* was monitored in northern Spencer Gulf, South Australia, between late 1986 and 1990 at a site within the influence of the thermal discharge from the Northern Power Station, and at a Gulf ambient site. *P. sinuosa* growth was also monitored in Pt Paterson, a large shallow bay surrounded by extensive mudflats, immediately to the south of the power station, but beyond the influence of the thermal plume.

P. sinuosa meadows adjacent to the power station show relatively minor reductions in growth characteristics (leaf blade biomass, productivity, and leaf growth) compared to those in Gulf ambient conditions, despite the fact that summer water temperatures adjacent to the discharges are consistently slightly higher than Gulf ambient and have reached 28°C, a temperature comparable to the highest field temperatures previously recorded for *Posidonia*.

However, in the naturally warm waters of Port Paterson, where average summer water temperatures are marginally higher than those within the influence of the thermal plume and where intermittent peak temperatures exceed 30°C, *P. sinuosa* has significantly reduced productivity, standing biomass, blade length and blade growth rate, typical of *Posidonia* species in marginal environments.

Despite the minimal effects of the current discharge on the seagrasses, the evidence from Pt Paterson suggests that in northern Spencer Gulf where summer temperatures are more typical of a subtropical than a temperate marine environment, *P. sinuosa* is near the upper limits of its temperature tolerance during the hottest time of the year. Should there be localised increases in maximum water temperatures in the Gulf from future thermal discharges (>30°C), there is the potential for more widespread occurrence of stunted seagrasses such as found in the shallow waters of Pt Paterson. One possible consequence of this could be localised increase in the movement of sediments on the sloping banks of the Gulf channel.

KEY WORDS: seagrass growth, water temperature, Spencer Gulf

Introduction

Spencer Gulf, South Australia, extends about 200 km inland to the arid mid north of South Australia (Fig. 1). Northern Spencer Gulf is defined as that portion of the Gulf north of 33°S. The waters of the northern Gulf are characterised by high summer salinities, 48 (Nunes & Lennon 1986), and summer temperatures in the mid to high 20s°C (Ainslie *et al.* 1989).

Shepherd (1983) found that the subtidal benthic communities were "impoverished in terms of the overall species richness" and concluded that this may be indicative of a stressed hypersaline environment. He suggests that it is critical that the component parts of the biological system of the northern Gulf "should receive very detailed study to determine its capacity to receive additional stresses".

The extensive seagrass meadows are an important component of the biological system of the gulf, as a habitat and nursery region, for their intrinsic conservation value, and also for the role they play in stabilising sediments, particularly the sloping banks of the Gulf channel[1].

In 1955 a 90 Megawatt (MW) thermal power station, Playford Power Station, was established on the eastern shore of northern Spencer Gulf, south of the city of Port Augusta (Fig. 1); by the 1960s the capacity had been increased to 330 MW. The cooling water discharge from this development resulted in surface water temperatures about 6°C above ambient near the power station, with only occasional incursions of the water to the intertidal regions (Ainslie *et al.* 1989).

In the late 1970s the decision was made to proceed with the development of a new power station of up to a possible 750 MW (Fig. 1), with the ultimate potential to discharge 4 million cubic metres of warmed seawater a day to the Gulf, more than doubling the volume of water discharged at 6°C above Gulf ambient (Ainslie *et al.* 1989), and with predictions of localised but noticeable increases in temperatures of gulf waters.

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[1] HAILS, J. R. (1982). Submarine geology, sediment transport, hydrodynamics and quaternary history of northern Spencer Gulf, South Australia. Seminar on the Research Needs for Management of the South Australian Gulfs. Australian Marine Sciences and Technologies Committee, Adelaide, 10 November 1982, 45-52. Unpubl.

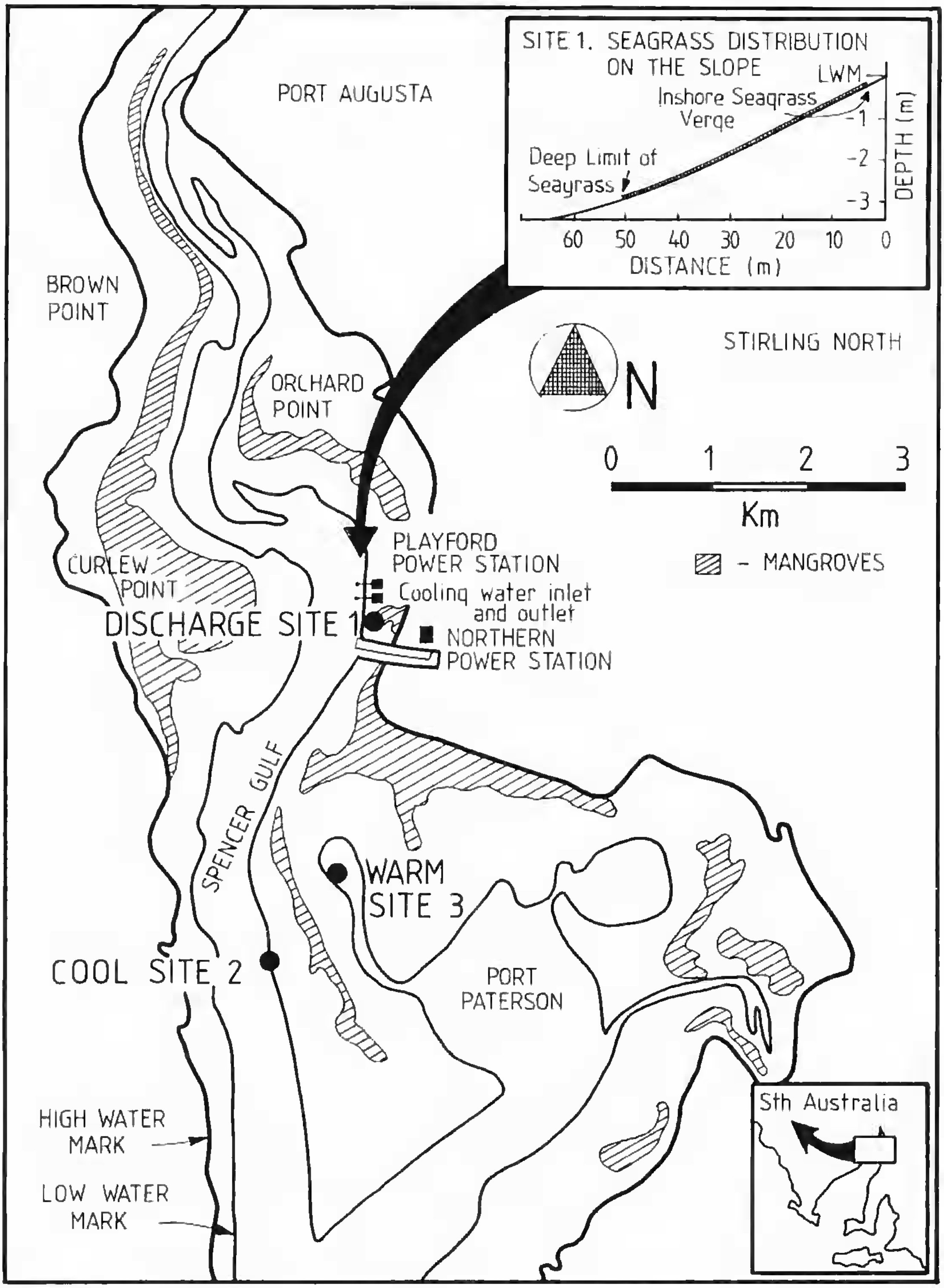

Fig. 1. Northern Spencer Gulf South Australia, Seagrass monitoring sites: (1) power station thermal discharge (2) Gulf ambient site remote from the discharge, and (3) Pt Paterson. Inset: seagrass distribution from low water mark to the Gulf channel at site 1.

Under some tidal conditions short term maxima were predicted to exceed 30°C in the vicinity of the power station outfalls[2].

The reported effects of thermal discharges on seagrasses range from large scale devastation resulting from temperature increases only a few degrees Centigrade above summer ambient (Thorhaug *et al.* 1978), to reduction in seagrass density (Robinson 1987) and changes in specific growth characteristics such as leaf thickness and biomass (Vicente 1977). Circumstantial evidence suggests that relatively small changes in temperature of inshore waters may also have indirect effects on seagrasses through increased bacterial and fungal attack (Rasmussen 1977).

Once seagrass meadows begin to deteriorate, erosion, siltation and reduction in water clarity may lead to a decline in the seagrasses beyond the direct influence of the discharge (Shepherd 1986). Other secondary effects such as increased impacts of grazing organisms may also accelerate the decline of seagrasses under stress (Shepherd *et al.* 1989).

Both *Posidonia australis* and *P. sinuosa* occur in northern Spencer Gulf but the latter species is dominant in the inshore meadows near the power stations.

This paper describes the result of a monitoring programme conducted to assess the effects of the increased thermal effluent from the first 500 MW development of Northern Power Station on the growth of the seagrass *P. sinuosa*, in the light of predictions of localised water temperature extremes approaching, or even exceeding, the upper known field temperatures for this species[2].

Materials and Methods

Preliminary field work was undertaken in the 1986-1987 summer season to establish sampling techniques. The results of the seagrass monitoring programme for the period 1987-1989 are reported in this paper.

Water temperatures and growth of *Posidonia sinuosa* were measured at three sites in northern Spencer Gulf (Fig. 1). The Gulf sites were established on transect lines, the elevation and location of which were confirmed relative to an established Port Augusta Power Station datum as part of a contiguous study of the benthic infauna of the northern Gulf (Ainslie *et al.* 1989). Site 1 is within 200 m of the power station and within the influence of the thermal plume of the new Northern Power Station; Site 2 is on the eastern side of the Gulf, 3.5 km south of the power station and beyond the predicted influence of the discharge plume[2]. Site 3 is in Port Paterson, a large shallow embayment, also beyond the predicted influence of the thermal plume. The naturally high water temperatures which have been recorded in Port Paterson[2] can be attributed to the insolation of the extensive surrounding mudflats.

20 m transects were established at each site about 5 m seaward of, and parallel to the inshore seagrass verge, all at a depth of about 0.3-0.5 m below LWD (a depth of up to 3.5 m during the highest tides).

At each site *in situ* water temperatures were recorded within the leaf blade canopy with portable data loggers in custom-built PVC waterproof housings, and fitted with 15 k thermistor detectors.

Air temperatures were recorded at the South Australian Bureau of Meteorology weather station located on the Northern Power Station site.

Our object was to estimate several measures of the biomass and growth rate of seagrass.

A wide range of sampling quadrat areas is cited in the literature for seagrass studies, depending on the leaf blade density, and the need to ensure that an adequate number of leaf blades is tagged for measurement. Shepherd (1983) used sub-samples of 50 leaf blades for detailed measurements of *Posidonia australis* leaf blade lengths and widths in Spencer Gulf. More recently Pollard & Greenway (1993) used samples of between 20 and 60 shoots in a leaf marking study of the productivity of three species of seagrasses in the warm waters of Cairns Harbour, Queensland. In this study 15 cm^2 steel framed quadrats were used to define measurement areas for each sampling site. Preliminary collections in the summers of 1985 and 1986 yielded information on the leaf blade numbers for the quadrat area. Sixty nine quadrats, randomly placed along the transect lines, were sampled at all locations; the mean number of leaf blades/quadrat was 34.5 ± 17. A decision was made to proceed with the field studies using five quadrats per site (averaging 170 blades/site). The sampling area/site was 1125 cm^2, comparable to that of a number of other productivity studies of seagrasses with a similar growth habit (Zieman 1974; Thorhaug *et al.* 1978; Walker & Mc Comb 1988).

Within the quadrats all seagrass blades were tagged and harvested using methods outlined in Zieman (1974). Harvesting was carried out at high tide, approximately every six weeks depending on weather conditions and underwater visibility.

Total blade lengths, incremental growth (length) and dry biomass of whole blades and incremental growth (productivity) were recorded for each harvest. Numbers of new shoots, i.e. shoots which grew subsequent to the initial tagging, and their growth and dry biomass were also recorded. A simple "shoot index" is derived which is the number of new

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[2] Electricity Trust of South Australia (1985) Northern Power Station Environmental Impact Statement. August 1985. Prepared by Kinhill Stearns. Unpubl.

shoots/m^2 (of seafloor area)/day expressed as a percentage of the original number of leaves tagged/m^2 for each sampling site. Blade widths were also recorded but were only used as a verification of the species collections.

Dry biomass was determined by drying freshly harvested blades to constant weight at 105°C, after removal of epiphytes with a stainless steel scraper and treatment in a 5% hydrochloric acid solution.

Results

Figure 2 presents a comparison of the Port Augusta summer air temperature and water temperatures at sites 1 to 3 during the summer of 1987-1988 with a 500 MW power station operating.

In the shallow seagrass beds of northern Spencer Gulf, air temperatures strongly influence the patterns of variation in the water temperatures at all three sites.

In mid-summer average water temperatures at all sites are between 20 and 25°C (Inset Fig.2). Short term fluctuations are most pronounced at site 3 in the shallow bay of Pt Paterson, and least evident at the Gulf ambient site 2. Overall, summer water temperatures are marginally higher at site 1 near the thermal discharge than at the Gulf ambient site, but consistently highest at site 3 in Pt Paterson (Fig. 2).

At all sites, despite the high summer temperatures, seasonal temperature variation is typical of temperate regions with winter water temperature dropping below 15°C, even at site 1 adjacent to the power station outfall.

The summer relativity of the water temperatures between the sites does not persist throughout the year. During the cooler months, Gulf ambient temperatures fall significantly below those of Port Paterson, which in turn is cooler than site 1 adjacent to the power station outfalls.

Productivity (mean growth, dry weight/m^2/d) of *Posidonia sinuosa* at sites 1 to 3, from November 1986, to August 1990, is shown on Fig. 3.

At the Gulf ambient site 2, and at site 1 near the power station cooling water outfall productivity shows a pronounced seasonal cycle with peaks between October and April. Although the seasonal cycle is less obvious in the seagrasses of the naturally-warmed site in Port Paterson, highest productivity values at this site were recorded in summer (Fig.3).

Productivity was consistently highest at the Gulf ambient site 2 and least at site 3 in Port Paterson, with highest recorded productivity being 3.7 ± 1.1 g/m^2/d, 3.1 ± 0.5 g/m^2/d, and 1.6 ± 0.3 g/m^2/d at sites 2, 1, and 3 respectively (Fig. 2).

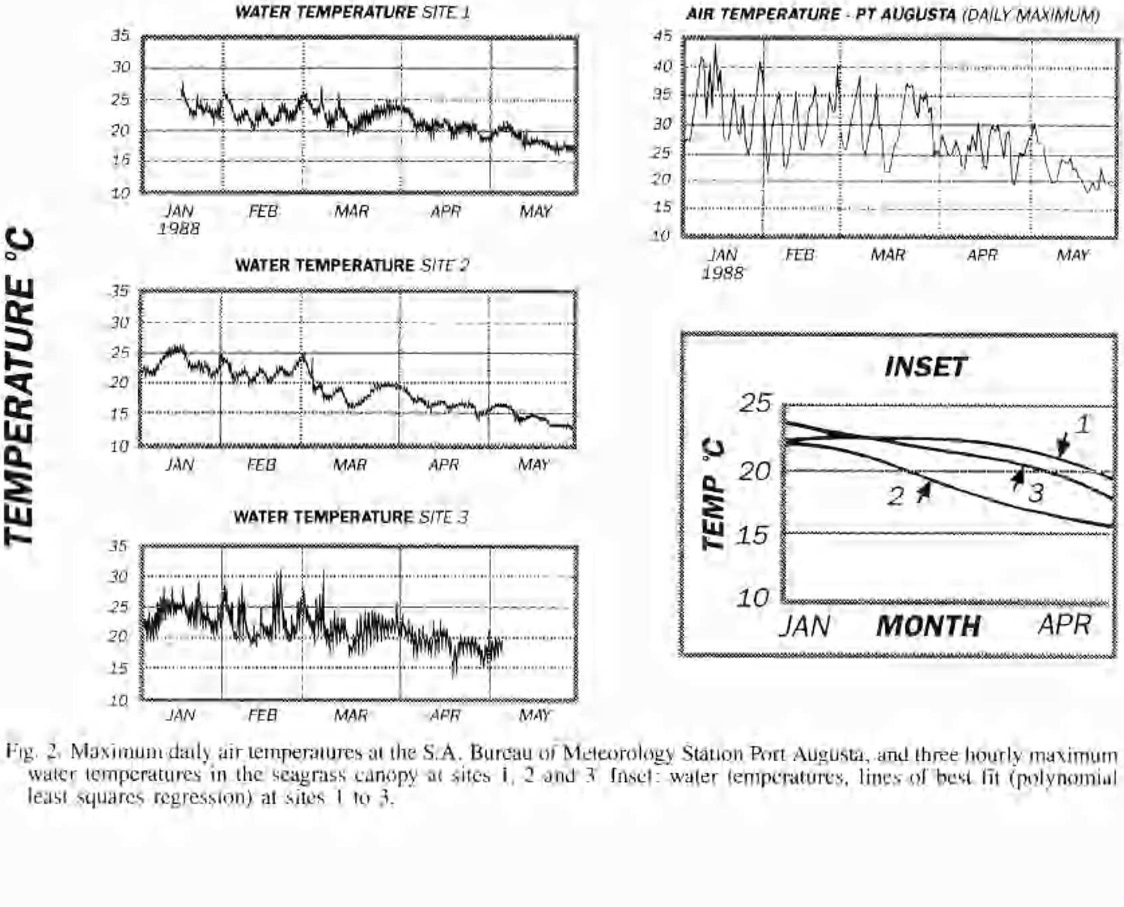

Fig. 2. Maximum daily air temperatures at the S.A. Bureau of Meteorology Station Port Augusta, and three hourly maximum water temperatures in the seagrass canopy at sites 1, 2 and 3. Inset: water temperatures, lines of best fit (polynomial least squares regression) at sites 1 to 3.

Productivity data for each site were compared, no *a priori* attempt being made to discern seasonal "cut-offs". Variances were not homogeneous (Bartlett's test, $P < 0.01$), and analysis of variance was therefore not used. However Kruskal-Wallis analysis showed significant differences between all three sites ($P < 0.01$), the greatest difference being between sites 3 and 1 and between sites 3 and 2 (Fig. 3).

Maximum mean standing biomass also occurs in summer (Fig. 4). As with productivity, the seasonal cycle is most pronounced at the cool Gulf ambient site 2, and least pronounced at site 3. The highest standing

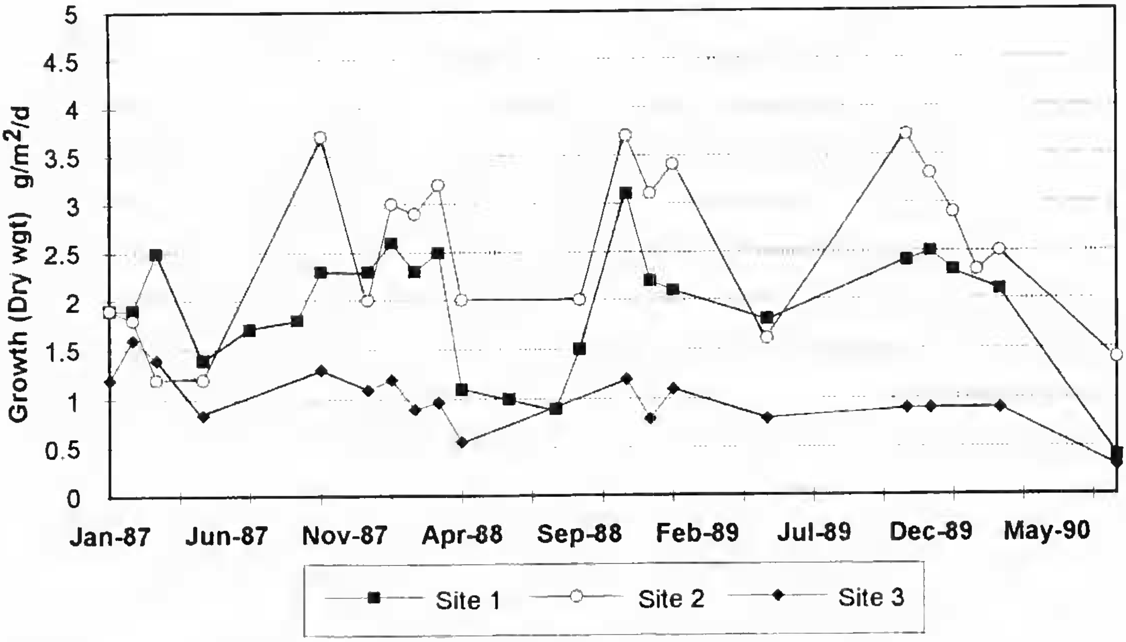

Fig. 3. Seagrass productivity, leaf blades, g/m^2/d (dry weight) at sites 1, 2 and 3.

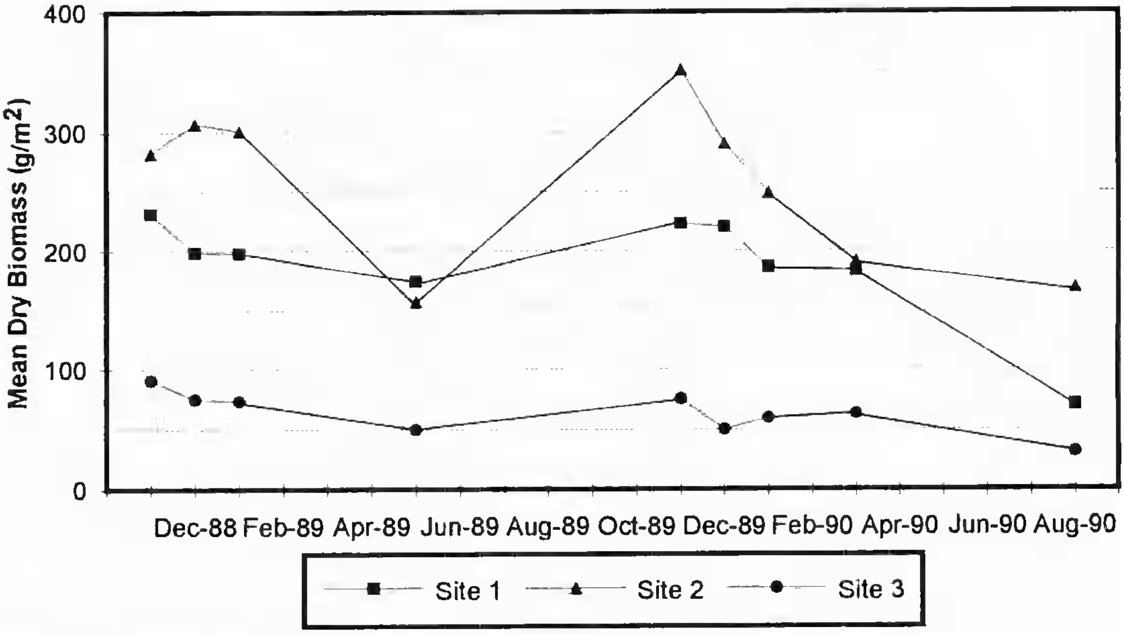

Fig. 4. Seasonal variation in mean standing biomass, leaf blades, g/m^2 (dry weight) at sites 1, 2 and 3.

biomass was recorded at site 2 in November 1989, 352 g/m^2. The highest summer mean standing biomass recorded at site 1 nearest the outfall was 231 g/m^2, in November 1988, while the mean standing biomass is consistently lower at site 3 in Port Paterson than at the other two sites with a summer maximum of 91 g/m^2 (Fig. 4), in November 1988. Analysis of variance using transformed data ($\log_{10}$) indicated significant differences between the standing biomass data of each of the three transects ($P<0.01$). An *A posteriori* multiple comparison test (Sokal & Rohlf 1969) indicated that although the differences between sites 3 and 2 and 3 and 1 were significant, sites 1 and 2 were not significantly different.

Comparisons were made of total blade lengths and blade growth rates for sites 1, 2 and 3 after combining the data collected for these measurements for January 1988 and January 1989.

Mean blade lengths were 438.9 ± 161.3 mm, 316.0 ± 95.0 mm, and 135.8 ± 50.3 mm at sites 2, 1 and 3 respectively (significantly different, ANOVA, $F = 367.6$, $F_{0.05,\ 2,804} = 3.0$).

Mean summer growth rates (incremental blade length) were 4.7 ± 2.8 mm/d, 3.6 ± 1.8 mm/d and 1.9 ± 1.1 mm/d at sites 2, 1 and 3 respectively. As with blade lengths there were significant differences between the sites (ANOVA, $F = 254.0$, $F_{0.05,\ 2,1686} = 3.0$).

Shoot production occurs all year round; the shoot index is highest at all sites during summer. Shoot indices are similar at sites 1 and 2, while the shoot index at site 3 is consistently much higher (about 2 to 3 times as high) than at the other two sites (Fig. 5).

Although no measurements were taken, field observations suggest that the epiphytic growth was consistently higher at site 1 near the outfall than at the gulf-ambient site 2, and higher again at site 3 in Pt Paterson. This was particularly evident for the serpulid worm *Eulospira convexis*, a species which has previously been demonstrated to thrive in the thermal outfall at Torrens Island Power Station in the Pt. River estuary, South Australia[3].

Discussion

A number of studies have indicated the susceptibility of seagrasses in subtropical regions to water temperature increases above ambient (Thorhaug *et al.* 1978; GESAMP 1984). In particular, there is evidence that many organisms, including seagrasses, are living close to the upper limits of their thermal tolerance during the warmest part of the year, and even short periods above the summer maxima can have significant adverse impacts (Zieman 1974; GESAMP 1984).

Larkum & Den Hartog (1989) hypothesise that the current distribution of species of the genus *Posidonia* in temperate regions, and the lack of evidence that any *Posidonia* species has ever occurred in tropical conditions in the past, may indicate that species of this genus have more limited temperature tolerance than species which occur in the tropics.

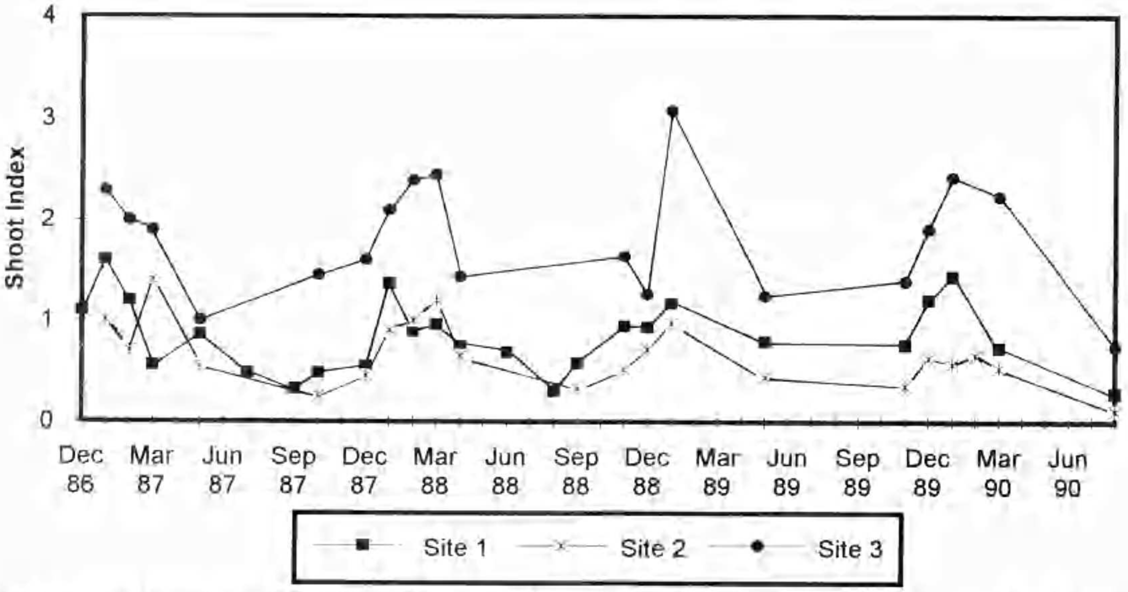

Fig. 5. Seasonal variation in shoot index (number of new shoots/m^2/d as a percentage of the original number of leaf blades per m^2 at the time of tagging) at sites 1, 2 and 3.

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[3] Host, W. M. (1977) Marine Biological Studies in Relation to the Operation of the Torrens Island Power Station. MSc. Thesis. Adelaide University. Unpubl.

In northern Spencer Gulf, although seasonal water temperatures range from as low as 11°C in winter to the mid to high 20s during summer (Ainslie *et al.* 1989), the high summer water temperatures are more typical of subtropical conditions than those normally associated with temperate coastal waters of the southern Australian coastline. (Subtropical conditions are defined as those where water temperatures generally range from 20-25°C, and do not exceed 30°C [GESAMP 1984]).

During mid summer, when air temperatures range to 45°C, the water temperature in the seagrasses at the outfall (site 1) is consistently about 0.5-1.5°C higher than at Gulf-ambient site 2 (inset Fig. 2). The difficulty in defining local ambient water temperatures is, however, illustrated by the difference between site 2 and site 3 on the southern shores of the large shallow embayment of Port Paterson. The latter site is also beyond the influence of the thermal plume, but exhibits consistently high average summer temperatures (inset Fig. 2), up to 2°C warmer than Gulf ambient (inset Fig. 2).

Comparison of summer temperature regimes between sites is complicated by the short term occurrence of extreme temperatures. Short term maximum temperatures at site 1 (28°C on two occasions, Fig. 2) are about 1°C higher than those recorded at the Gulf ambient site, and as high as the maximum field temperatures recorded prior to this study for Australian *Posidonia* species (Walker & McComb 1988). At site 3 which has the most pronounced diurnal variations the short term maxima recorded during summer exceeded 30°C on a number of occasions, more than 3°C higher than the peak temperature at the Gulf ambient site 2 (Fig. 2), and the highest field temperatures at which *Posidonia* species have been recorded.

Although seasonal data have been unavailable for *Posidonia sinuosa*, information on the productivity of a number of different species of seagrasses has been reviewed by Walker & McComb (1988) and Hillman *et al.* (1989). These authors found that seagrass species in temperate waters in general tend to show a pronounced seasonal variation with a distinct growing season in summer. However Walker & McComb (1988) found no clear seasonal pattern in the productivity of *Posidonia australis* in the semi-enclosed bays of Shark Bay, Western Australia, over a one year period. The water temperatures in Shark Bay ranged from about 18°C to more than 26°C, and maximum temperatures up to about 28°C have been recorded in this area (Walker & McComb 1988). Despite the fact that at all three sites in the present study summer water temperatures resembled the semi-tropical conditions of Shark Bay, the *P. sinuosa* growing at Gulf-ambient (site 2) and in the marginally warmer conditions adjacent to the power station thermal discharge (site 1), show seasonal fluctuation in both productivity and standing biomass, with maxima for both measures in the warmer summer months. Even at site 3, with the most extreme conditions, summer 'peaks' are evident in these features, although seasonal patterns are not as pronounced as at the other two sites. This persistence of summer peaks in productivity and standing biomass, particularly at sites 1 and 2, suggests that the *P. sinuosa* of northern Spencer Gulf may be more tolerant of extreme summer conditions than, for example, the *P. australis* of Shark Bay.

At all sites there was some variation between the values recorded from year to year for summer peaks of both productivity and standing biomass. This variation was, however, no more pronounced than natural year to year variations recorded in a number of recent studies of a range of temperate Australian seagrasses (Walker & McComb 1988; Hillman *et al.* 1989). Although the growth of the seagrass *P. sinuosa* differs between the three sites, the inter-annual comparisons indicate that, at any given site, the growth is comparable from year to year. There is no evidence of "deterioration" at site 1 adjacent to the power station, or at either of the two control sites, during the course of the current study.

Although numerous studies have documented the range of effects that artificially imposed temperature regimes may have on seagrasses, few have attempted to describe the progressive effects on growth characteristics which occur with incremental temperature increases above ambient. The exception is that of Thorhaug *et al.* (1978) who recorded detailed changes in growth of leaf blades, productivity and standing biomass (standing crop) in tropical and subtropical *Thalassia* stands subjected to incremental increases in water temperature above ambient.

Accepting that different species may have quite different temperature tolerances, it is nevertheless of interest to examine the similarity between *Thalassia* species with a subtropical distribution, and *P. sinuosa*, subjected to above-ambient temperatures in an environment where summer temperatures are already high in terms of the geographic distribution of this temperate species.

Thorhaug *et al.* (1978) report that, with increases as little as 1.5°C above summer ambient water temperature, growth per blade, productivity, and standing biomass of *Thalassia* declined to 64%, 60% and 82% respectively, of that at ambient temperatures and continued to decline sharply with incremental increase in above-ambient temperature. At 5°C above ambient the seagrass "disappeared" from the area (Thorhaug *et al.* 1978).

The maximum mean productivity recorded for *P. sinuosa* at site 1, with average summer water temperatures 0.5-1.5°C above Gulf ambient and short term peak temperatures up to 1°C higher than short term Gulf ambient peak temperatures, was 84% of that recorded at site 2. A contributing factor to this lower productivity is the lower rate of blade growth at site 1, mean growth per blade being only about 77% of that of blades at site 2 during the warmest time of the year. Despite the fact that over the period December 1988 to August 1990 standing biomass of *P. sinuosa* at site 1 was not statistically significantly lower than at site 2, the maximum mean standing biomass recorded during this period at site 1 was only about 70% of the maximum recorded during the same period at site 2 (Fig. 4).

At site 3 in Port Paterson with average temperatures consistently 2°C higher than Gulf ambient and peak temperatures 3°C higher than ambient peaks, productivity, standing biomass, total blade length, and blade growth are all significantly lower than at the Gulf ambient site (only 30-40% of Gulf ambient values for maximum mean productivity (Fig. 3), maximun mean standing biomass (Fig. 4), and mean summer blade lengths and growth rates.

There is a lack of published information on *P. sinuosa* with which to compare the growth information from the present study. Neverauskas (1988) examined the effects of shading on a mixed *P. sinuosa* and *P. angustifolia* stand at a depth of 11-12 m, in an area removed from any land based discharge. In winter, at the commencement of the shading experiments Neverauskas recorded a mean standing biomass of 100 g/m^2. In this study the winter standing biomass of *P. sinuosa* at both sites 1 and 2 ranged from about 125 g/m^2 to 175 g/m^2, while the winter standing biomass at site 3 in Pt Paterson was about 50 g/m^2 (Fig.4). Accepting that comparisons made between seagrasses from different localities and depths can be misleading (Ainslie 1989) these biomass values nevertheless suggest that the seagrass stands at both site 1 and site 2 are at least as vigorous as in a location deliberately chosen for its apparent "health". The *P. sinuosa* at site 3 in Pt Paterson, on the other hand, is less vigorous not only in comparison with the other sites in the northern Gulf, but also in comparison to that examined by Neverauskas (1988).

This paper does not rule out the possibility that, in the higher water temperatures at site 1, and particularly at site 3, indirect factors lead to the reductions in seagrass growth. For example Neverauskas (1988) has shown that shading of a mixed *Posidonia sinuosa* and *P. angustifolia* stand with shade cloth (to simulate epifaunal growth on the leaf blades) resulted in significant decline in standing biomass (standing crop), and leaf blade length. It is possible that indirect effects from shading caused by relatively greater epiphytic growth at site 1, and particularly site 3, may have contributed to the reduced productivity, leaf blade length and growth, and dry biomass at these sites compared to site 2.

Neverauskas (1988) also found that with progressive periods of shading, the shoot density declined, suggesting a reduction in the appearance and growth of new shoots. In the present study new shoot production (with respect to leaf blade density) was very similar at sites 1 and 2 throughout the year. Particularly during the summer, however, new shoot production as a proportion of the leaf blade population was 2 to 3 times higher at site 3 in Port Paterson than at the other two sites. If shading by epiphytic growth is a contributing factor to the observed reduction of standing biomass and productivity in this study the comparison to the results of Neverauskas (1988) does not extend to new shoot production. However, while in Neverauskas's study whole shoots were shaded, in this study the epiphytic growth shaded individual leaves, with more shading of older leaf blades. Although it seems likely that this shading by epiphytes contributes to a reduction in standing biomass and productivity, the consistently higher relative production of new shoots at site 3 suggests a response similar to that of terrestrial grasses, where cutting back to reduce shading by old leaves can result in increased leaf production, tillering and branching (Hendrick & Black 1986). The stunted growth of older leaf blades at site 3 may expose the new blades to more light. One result of this higher shooting frequency in Port Paterson is that, despite the stunted growth of the *P. sinuosa*, the shoot density does not decline; there is no ongoing deterioration of the stands as observed by Neverauskas (1988) in artificial shading experiments.

Salinities at all three sites are high, as they are throughout the northern Spencer Gulf, in summer reaching about 48 (Nunes & Lennon 1986). Although information on the salinity tolerance of *P. sinuosa* is not well documented, *P. australis* survives in a wide range of estuarine salinities up to 57 (Cambridge & Kuo 1979). Tyerman *et al.* (1984) have shown that the salinity tolerance of *P. australis* is, in part, due to the physical shielding of the sheaths of older leaf blades surrounding the bases of the youngest lamina. The leaf sheaths of *P. sinuosa* are at least as robust as that those of *P. australis* (Cambridge & Kuo 1979) suggesting that the same mechanism for salinity tolerance operates in this species. Although this paper does not rule out the fact that a combination of factors (high temperature and high salinity) may lead to the stunting of the seagrasses in Port Paterson, the high water temperatures would appear to be the key variable between the sites.

From their studies of thermal effects on *Thalassia* Thorhaug *et al.* (1978) suggest tentatively that increases above ambient water temperatures of about 1.5°C may be considered "rational" with respect to the limited impact on seagrass and associated communities. In the current study, the maximum summer temperatures at site 1, near the thermal discharge, fall within this category. The results of this study also support the contention that the overall change in *P. sinuosa* growth is relatively minor with this magnitude of temperature increase above ambient, less than the order of change considered acceptable by Thorhaug *et al.* (1978) for *Thalassia*. In Pt Paterson, in consistently higher above-ambient summer water temperatures than recorded near the thermal outfall, *P. sinuosa*, although exhibiting stunted growth characteristics of this species in marginal environments (Cambridge 1974; Cambridge & Kuo 1979), persists with no indication of ongoing decline, in terms of biomass, productivity, leaf blade growth and length, or areal extent of local distribution.

It has been proposed that the sediment stabilising role of seagrasses may be particularly important in maintaining the integrity of the sloping banks of the channel of northern Spencer Gulf[1]. While the stunted seagrasses on the relatively protected shores of Pt Paterson survive without any evidence of ongoing decline, if the seagrasses in the more exposed Gulf channel (for example adjacent to the thermal outfall) were to be subjected to further, small summer water temperature increases, resultant stunted growth could lead to increased localised mobilisation of the shoreline sediments. This, in turn, could lead to longer term effects on the spatial distribution of seagrasses in this area. Given this possibility, any consideration of future development of the power station should recognise the need to ensure that there is no increase in the maximum temperature of the discharged cooling water.

Acknowledgments

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